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PHYSICS.—*Determination of the zonal variation of the equivalent focus.* E. D. TILLYER. Bureau of Standards. Communicated by FRED. E. WRIGHT.

The method of lens testing developed by Hartmann[1] in 1904 has given a very efficient means of determining the grouping of the light rays after passage thru a lens system. This method is laborious and difficult when applied to the zonal variations of the equivalent focal length. In the present paper it is proposed to show how one set of measures gives both the variations of the position of the focus and of the equivalent focal length: also, by making several sets in light of different wave lengths, the axial and oblique chromatic aberrations can be obtained.

A diagramatical sketch of the apparatus used, is given in figure 1. A nearly parallel beam of light from a distant monochromatic source falls upon a metal plate P pierced with small holes, only two of which are shown, forming light rays which pass thru the lens system and are refracted in the normal manner. A shadow photograph is taken upon a plate placed close to the lens, a second at a considerable distance on the other side of the focus. These shadow images are not as sharply defined as when both exposures are made close to the focus. If, however, care is taken, a dark center diffraction disk can be obtained which increases the ease and accuracy of a setting.

Now consider the position of any ray R (fig. 1) with reference to the axial ray. Let a, b equal the distances of this ray from the

[1] Hartmann, Zeitschr. f. Instrumentenkunde. 1904.

axis in the planes A and B respectively, let d equal the separation of these two planes and v the distance from A of the intersection of this ray with the axial ray, then we have

$$v = \frac{a\,d}{a+b}$$

which is the position of the focus as given by Hartmann. A variation of v as Δv from the limiting paraxial value is the spherical aberration.

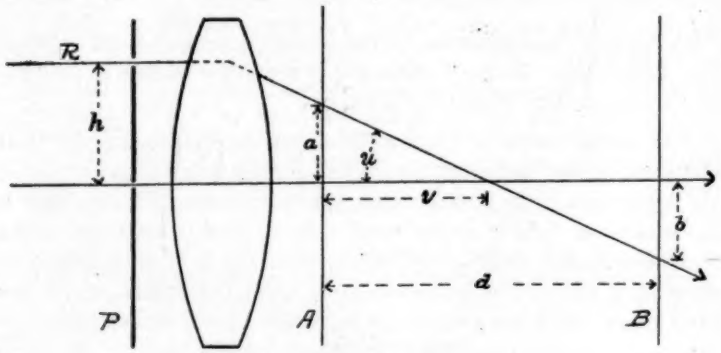

Fig. 1

Abbe has shown that, if we assume no spherical aberration, a lens will be free from coma for points near the axis when the "sine condition" is fulfilled. If the object is at infinity this reduces to

$$E = \frac{h}{\sin u}$$

where E is the equivalent focal length, h is the distance from the axis of the entering ray and u is the angle this ray makes with the axis after refraction. If E varies from the limiting zero value, as ΔE when h varies, the lens has a different equivalent focus for each zone. It can be shown in a lens without artificial stops and with spherical aberration, that the corresponding condition for freedom from zonal variation of equivalent focus (coma near the axis) is $\Delta E - \Delta v = 0$.

The metal plate used for isolating the individual rays has been calibrated, and the height h determined; the angle u can be obtained from

$$\tan u = \frac{a+b}{d} = \frac{a}{v},$$

and consequently E and $\Delta E - \Delta v$. This set of measures can be repeated for different wave lengths, and the variations in the quantities determined; from Δv we find the axial chromatic aberration and the departure from the Gauss condition, and from $\Delta E - \Delta v$, the oblique chromatic aberration and the variation of coma with color.

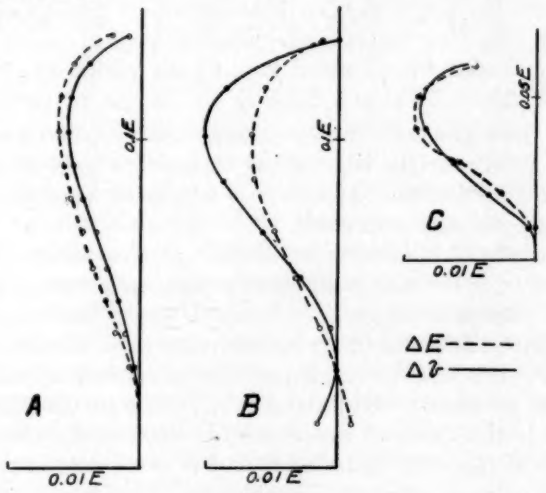

Fig. 2

The diaphragm plate, generally used with moderate size lenses, has holes of 1 mm. diameter arranged in a line and located at about 3 mm. intervals. The error in the known position of the holes is less than 0.005 mm. which corresponds to an error of about one part in ten thousand in ΔE for the edge ray of an ordinary small lens. The shadowgraphs are easily measured on a small Zeiss comparator with sufficient accuracy for rays somewhat

distant from the center. Near the axis it is almost impossible to obtain an accurate value of either ΔE or Δv and the problem becomes physically indeterminate.

This method was first tried upon a telescope objective of 320 mm. equivalent focus, the trigonometric residuals of which were already known.

TABLE 1

TELESCOPE OBJECTIVE, $E = 320$, $\lambda = 0.55\ \mu$. RESIDUALS IN HUNDREDTHS OF A MILLIMETER

h in mm.		3	6	9	12	15	18	21	27.5
Obs.....	Δv.....	+0	+17	−1	−7	−1	−7	−1	
Obs.....	ΔE-Δv.....	+4	− 2	+4	−8	0	−2	+3	
Comp.....	Δv.....	0	− 1	−2	−3	−5	−6	−5	+5
Comp.....	ΔE-Δv.....	0	0	0	+1	+1	+1	0	−1

From these residuals it is seen that the probable error of a determination near the edge of the objective is only a few hundreths of a millimeter. Moreover it is evident that this objective is exceptionally well made.

The results of measurement of the spherical aberration and departure from the sine condition for three photographic objectives are plotted in figure 2. Curves A and B were made from high speed anastigmats with an aperture ratio of about F 3.5 while curve C is an older much used type of symetrical anastigmat having an aperture ratio of about F 7.7. One peculiar feature of curve B is the difficulty experienced in determining the relative positions of the zero values of E and v, the v curve apparently having a point of inflection near the axis. This may be due to a small error in grinding the surface, to an error in the measurements, or to a true aberration in this type of lens. Some evidence exists that this is a true aberration since the actual coma found in this lens changes sign at only a small angle with the axis. Both lenses, however, are remarkable for their freedom from aberrations and for the care taken in their construction.

CRYSTALLOGRAPHY. *The change in the crystal angles of quartz with rise in temperature.* FRED. E. WRIGHT. Geophysical Laboratory.

Crystallographers agree that in the development of the science of crystallography the two minerals, quartz and calcite, have played an exceedingly important rôle. Quartz was the first crystal substance to attract the attention of the ancient Greeks. They observed that its crystals are bounded by plane and not curved surfaces, as is the case in plants and animals; and they named it "crystal," i.e., clear ice, on the assumption that it had been formed from water thru the action of intense cold. Later they found that other substances had different but equally characteristic shapes and they accordingly extended the term "crystal" to signify the state of being bounded by flat surfaces rather than to denote the mineral quartz to which the name "rock crystal" is still applied occasionally. Further observations on crystals were not made until 1669, when Nicolaus Steno, a Danish physician, found that the angles between any two corresponding quartz crystals were the same even tho the shapes and sizes of these faces varied from crystal to crystal. Steno's law of the *constancy of crystal angles* is of fundamental importance and on it all subsequent work in crystallograpy has been based. Steno's observations were made at room temperature and under ordinary atmospheric pressure, and practically all subsequent measurements of crystal angles have been made under similar conditions of pressure and temperature, with the result that these two factors have been less carefully considered by crystallographers than their importance possibly merits.

We may look upon a crystal as a system of forces which finds expression in the development of the crystal faces and in the other crystallographic properties and which, in turn, exerts a definite influence on external forces, either physical or chemical, within the range of its action. This system is not invariant but has two degrees of freedom, temperature and pressure, and, even tho their effects may be relatively slight, yet their recognition and study should furnish data of value. In physical chemistry the investigation of the temperature-pressure effects on chemical-

physical systems has led to results of the greatest interest. In crystallography the relations between the differential changes in the crystallographic properties and the attendant differential changes in the optical and other constants should lead to differential equations which on integration would state the relations between the two systems of forces (crystallographic and physical) and thus give us information on the character and order of magnitude of the crystallographic forces themselves. It is essential in this connection to measure not only the changes in the crystallographical and optical constants with temperature and pressure but also the specific heats at the different temperatures (energy changes). The measurement of these properties on a few selected minerals is now being carried out at this Laboratory. In the present preliminary paper the results of the measurements of the changes in the crystal angles of quartz with temperature are presented briefly.

Method and apparatus. The quartz crystals were measured on the thermal two-circled goniometer described recently in this journal.[1] With this goniometer the position of the normal to each crystal face in space was fixed by two angles (angular polar distance and azimuth angle) for each measured temperature. The crystal was mounted in platinum jaws and securely fastened. No effort was made to adjust the crystal accurately because it was evident that any mechanical device consisting of different materials would not remain fixed in position over a temperature range of 1200°. The entire crystal was first measured at room temperature and then the furnace heated to a definite temperature, and held there 5 or 10 minutes; at this temperature the entire crystal was remeasured, the temperature being held constant during the measurement and the angular values on several of the faces repeated to insure constancy of position of the crystal during the readings. This procedure was repeated at each temperature of measurement up to 1250°. By this method adjustment troubles are eliminated and the measurement of the entire crystal is complete for each temperature and independent of previous adjustment and of any slight shifts in position which may have occurred.

[1] Journ. Wash. Acad. Sci., **3**: 396–401. 1913.

From the position angles of the faces thus measured the angles between the unit rhombohedrons over the pole were computed; also the angle between the unit rhombohedron and the prism face immediately below it.

During the measurements the adjustment of the goniometer was tested and found satisfactory. Readings were made to $\frac{1}{4}'$ of arc, the circle being graduated to $\frac{1}{2}'$.[2] At the high temperatures the light from the furnace itself is so intense that an arc light is re-

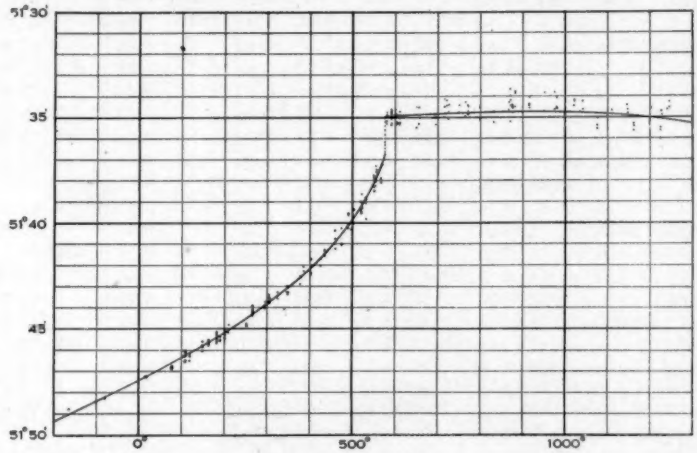

Fig. 1

quired for illuminating the signal. The light of the furnace was cut out to a large extent by means of a blue filter (Wratten tricolor blue) which absorbed all of the red and yellow and most of the green of the spectrum, colors which are most intense in the furnace, whereas the arc light emits relatively more blue light. At 1250° the signals observed thru this filter were perfectly sharp and the measurements were as easy to make as at room temperatures.

The results of measurements are listed in Table 1 and are represented graphically in figure 1.

[2] In making the readings the quarters of minutes were recorded as follows: $\frac{1}{4}' = 1.$; $\frac{1}{2}' = 1'$; $\frac{3}{4}' = 1:$; this method of indicating the quarter minutes was found convenient and satisfactory in practice.

TABLE 1

TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES
18	0.0h	180	1.9k	305	3.6f	426	5.7f	531	8.2g	602	11.8h
20	0.0e	181	2.0d		3.9f		6.1f		8.5g		12.2h
	i		1.6d		4.1f	437	5.9e		7.9g		12.4h
21	0.0a		2.1d	326	4.0e		5.4e		8.0k		12.6h
	f	185	1.9e		3.8e		5.8e		7.8k	613	12.0k
	g		1.7e		3.5e		6.0e	552	9.0d		11.9k
22	0.0b		1.9e		3.7e	461	6.0b		9.2d		12.3k
	k		2.0e	330	4.0l		5.9b		9.6d	614	12.2l
23	0.0c		2.3e		3.9l		6.3b	554	8.9b		12.2l
	d	190	1.9l		3.8l		6.9b		9.7b		11.5l
	l		1.8l		3.9l	484	7.0g		9.7b		12.0l
79	0.5i		2.1l		4.2l		7.6g		9.1c		12.5l
	0.4i		2.2l	341	3.9i		6.3g		9.2c	636	12.2e
	0.7i		2.2l		4.0i		7.0g		9.0c		11.9e
108	1.1e	203	1.8i		4.3i	494	7.5d		9.0c		12.2e
	0.7e		2.0i	344	4.2k		6.9d	560	9.6l		12.4e
	1.0e		2.2i		4.0k		7.7d		8.9l	647	12.7d
110	0.8f	206	1.8a		4.3k	500	7.0h		9.6l		12.3d
	1.2f		2.2a	346	3.9c		7.1h	552	9.5h		11.9d
	1.2f		2.2a		4.0c		7.6h		9.5h	670	12.3c
111	1.1c	213	2.1f		3.8c		7.7h		9.7h		11.7c
	1.0c		2.2f		3.9c	504	7.2c		9.5h		12.2c
	0.7c		2.3f	377	4.2b		7.5c	565	9.2d		13.3c
	0.7c		2.2f		4.7b		7.6c		9.9d	703	12.2h
	1.2h	255	2.4c		4.8b	519	7.8l		10.3d		12.6h
	1.2h		2.4c		4.4b		7.9l	582	11.5f		13.1h
	1.5h		2.5c	392	4.4h		7.5l		12.1f		12.7h
122	1.0a	267	2.9g		5.0h		7.8l		12.3f	713	12.2g
	0.8a		3.2g		5.2h	521	8.6b	583	12.5d		12.5g
	0.8a		3.4g		5.3h		8.0b		12.5d		12.8g
151	1.2g		3.5g	408	5.0d		7.9b		11.9d	722	12.3i
	1.5g	272	3.0h		4.9d		8.2b	592	12.0g		12.6i
	1.5g		3.3h		5.6d		8.2f		12.5g	731	12.8c
	1.7g		3.1h	426	5.0c		8.0f		12.2g		12.2c
163	1.5b		3.4h		5.2c		7.5f		12.9g		12.4c
	1.7b	294	3.5d		5.6c	531	8.2e		13.1g		12.1c
	1.6b		3.2d		5.0c		8.4e	595	12.4c		13.0c
	1.7b	302	3.5b		5.3f		8.2e		12.0c	732	12.8e
180	1.8k		3.1b		5.4f		8.2e		11.9c		12.4e
	1.7k		3.7b		5.8f		8.2e	602	11.8h		12.1e

TABLE 1—CONTINUED

TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES	TEMPERATURE IN DEGREES	DECREASE IN ANGLE ρ IN MINUTES SERIES
750	12.3d	806	12.7e	865	13.6l	938	12.9d	1042	12.6h	1144	11.3c
	12.9d		12.6e		13.6l		12.9d		11.6h		13.6c
	11.7d		12.7e	866	12.7g	971	12.7c		13.0h	1203	11.6c
769	12.7i		12.9e		13.4g		12.6c	1058	11.7c		11.6c
	13.0i	857	13.6d		13.4g		11.8c		12.1c		11.2c
	12.9i		13.6d		12.5g		13.2c		12.2c		11.3c
770	12.8k		12.1d	874	12.4i	975	13.1l		11.3c	1232	12.5g
	12.9k		12.8h		12.4i		13.4l		11.0c		12.3g
	12.5k		13.1h	916	12.7k		13.6l	1109	12.6l		12.4g
	12.5k		13.2h		12.8k		12.3l		13.6l		11.3g
	12.2k	862	12.7c		13.2k	993	11.5i	1143	12.4k	1235	12.6l
	12.7k		12.6c	929	12.8e		11.7i		12.6k		13.6l
788	12.8l		12.8c		13.2e	1020	12.8k		12.8k		12.7l
	12.2l		12.7c		12.6e		13.0k	1144	11.6c		12.2l
	12.0l	865	12.6l		12.1e		13.0k		11.9c	1239	12.7k
	12.7l		12.9l	938	13.3d	1042	12.6h		11.2c		12.9k

NOTE: In this table the different sets of readings are lettered thus: *a* readings made on October 4; *b*, on October 7; *c*, on October 8; *d*, on October 10; *e*, on October 15; *f*, on October 17; *g*, on October 18; *h*, on October 22; *i*, on October 24; *k*, on October 27; *l*, on October 28, 1913. All crystals measured were from Herkimer Co., N. Y., and were kindly loaned to the Laboratory by the U. S. National Museum (Specimen No. 82925).

In Table 1 the computed changes in the polar angle ρ for the unit rhombohedron $(10\bar{1}1)$ are given in place of the measured angles, which of themselves have no direct significance because the crystals were purposely not accurately adjusted before the measurement.

The heavy curve in figure 1 represents the average value of the observations. At 575° it has a noticeable discontinuity which marks the transformation of α into β quartz; this is accompanied by a noticeable change in volume and also in the optical and crystallographical properties. At the inversion temperature the reflexion signals from all of the faces, both rhombohedron and prism, become temporarily (2 to 5 seconds) indistinct; the sharp signal widens out into a hazy patch of light, moves noticeably and

finally regains its original sharpness but has usually shifted its position noticeably in the field.

The form of the curve below 575° (α-quartz) suggests an exponential curve. To test this conclusion the first, second and third derivatives were formed by the method of differences between values at constant intervals on the curve. The curves of these derivatives were similar in shape to the original curve, thus proving that the original curve can not be adequately represented by an ordinary polynomial equation up to the fifth degree. Accordingly an exponential function of the form

$$y = at + b\ (e^{t} - 1)$$

was tried with the following results, the constants a and b having been ascertained from the observed values by the least square method:[3]

$$y = 51°47'.4 - \left\{0.0113173t + 0.01335\left(e^{\frac{t}{100}} - 1\right)\right\}$$

Expressed in absolute temperatures this equation becomes

$$y = 51°51'.4 - \left\{0.0113173T + 0.00087093e^{\frac{T}{100}}\right\}$$

[3] This function is the simplest combination of an algebraic with a transcendental function. The introduction of the exponential series into the equation has the effect of rapidly increasing the slope of the curve near the inversion point. On forming the second and third differential quotients of this function we find that $\frac{d^3y}{dt^3} = \frac{d^2y}{dt^2}$. Now in mechanics the first differential quotient is termed the velocity and the second differential quotient, the acceleration. The product, mass times acceleration, defines the force acting. If we interpret the above differential quotients from this view-point we find that the rate of change in acceleration of angular velocity with temperature at any time is equal to the acceleration (force) itself. This condition implies a force which increases with greatly increasing rapidity as the temperature rises and indicates that at some definite temperature (575° in quartz) the force has reached such a magnitude that the crystal forces can no longer withstand it; a profound change in the internal arrangement results to relieve the stresses set up. Simple inspection of the curve indicates that its rise near the inversion point is so great that such a condition can not continue far above 575°.

It is interesting to note that the exponential function above is similar in form to that suggested by Dr. Adams in the last number of this Journal, p. 469. All such equations reduce on differentiation to the form $\frac{d^3y}{dx^3} = K\frac{d^2y}{dx^2}$ and indicate clearly that the curve they represent can not be expressed by a simple polynomial with positive exponents. The introduction of the exponential function provides more effectively for the extra rapid rise or fall and consequent straightening out of the curve than the addition of an extra term to a polynomial series.

The agreement between the values computed from the first equation and the data of observation is indicated in Table 2.

TABLE 2

TEMPERATURE	OBSERVED	COMPUTED	DIFFERENCE
0°	51° 47′.4	51° 47′.4	0′.0
100	51 46 .4	51 46 .3	+0 .1
200	51 45 .1	51 45 .1	0 .0
300	51 43 .8	51 43 .8	0 .0
400	51 42 .1	51 42 .2	−0 .1
500	51 39 .8	51 39 .8	0 .0
550	51 38 .0	51 37 .9	+0 .1
575	51 36 .7	51 36 .7	0 .0

A check on these values was obtained from the data on the expansion of quartz parallel to the principal axis as determined by Randall[4] and the specific volumes of quartz kindly furnished me by Dr. Sosman of this Laboratory. These values are listed in Table 3. In Randall's paper the true expansion coefficients only are given. From them the total expansion listed in Table 3 was found by Euler's method of mechanical quadrature.

TABLE 3

TEMPERATURE	SPECIFIC VOLUME	TOTAL EXPANSION PARALLEL TO AXIS	TOTAL EXPANSION NORMAL TO AXIS	CRYSTAL ANGLE ρ FOR $10\bar{1}1$ CALCULATED	CRYSTAL ANGLE ρ FOR $10\bar{1}1$ OBSERVED	DIFFERENCE
0°	0.3772	1.00000	1.00000	51°47′.4	51°47′.4	0′.0
100	0.3785	1.000806	1.00132	51 46 .5	51 46 .4	+0 .1
200	0.3803	1.001744	1.00317	51 45 .1	51 45 .1	0 .0
300	0.3821	1.002867	1.00504	51 43 .8	51 43 .8	0 .0
400	0.3845	1.004249	1.00752	51 42 .0	51 42 .1	−0 .1
500	0.3877	1.006072	1.01079	51 39 .6	51 39 .8	−0 .2

The changes in the crystal angle ρ of the unit rhombohedron with temperature as calculated from these data are given in column 5, the observed values in column 6 and the differences in column 7. The agreement between observation and theory is excellent, better in fact than might well have been expected from the data used. Such close agreement should be considered more or less accidental.

[4] Phys. Rev., **20**: 10–37. 1905.

It is of interest to note the similarity in shape between the curves representing the changes in other properties of quartz.[5] These are listed in Table 4 and are represented graphically in figure 2 after reduction to a common unit. From these curves it is evident that whatever it is that produces the changes in quartz as the inversion point is approached, the relative changes produced bear practically linear relations to one another. This applies to crystal angles, total expansion, specific volume, birefringence and circular polarization. The curves representing refractive indices as determined by Rinne and Kolb[6] are, however, somewhat different in shape. No satisfactory explanation of this divergence has yet been found. A redetermination of the refractive indices of quartz at various temperatures is being undertaken in this Laboratory.

TABLE 4

TEMPERATURE IN DEGREES	CRYSTAL ANGLE ρ OF 1011	DIFFERENCE IN PER CENT	TOTAL EXPANSION PARALLEL TO AXIS	DIFFERENCE IN PER CENT	SPECIFIC VOLUME	DIFFERENCE IN PER CENT	BIREFRINGENCE	DIFFERENCE IN PER CENT	EXCESS SPEC. HEAT OF QUARTZ OVER MICROCLINE	DIFFERENCE IN PER CENT
	51°		1.00		0.3		0.00		0.0	
0°	47′.4	0	0000	0	772	0	910	0	000	0
100	46 .4	11.0	0806	11.1	785	9.6	900	9.5	053	6.4
200	45 .1	24.4	1744	24.0	803	22.4	887	21.8	123	14.9
300	43 .8	38.6	2867	39.6	821	36.0	872	36.2	223	27.0
400	42 .1	56.1	4249	58.6	845	53.7	853	54.4	366	44.4
500	39 .8	81.0	6072	83.8	877	77.3	827	79.4	598	72.5
550	38 .0	100.0	7250	100.0	908	100.0	805	100.0	825	100.0

In order to form an idea of the energy relations involved I obtained from Dr. White of this Laboratory the values of his deter-

[5] The equations which represent the changes in the different properties of quartz with temperature are:

Birefringence, $y = 0.00910 - \left\{0.115735t - 0.171195\left(e^{\frac{t}{100}} - 1\right)\right\}10^{-5}$;

Specific volume $y = 0.3772 + \left\{0.154944t + 0.202369\left(e^{\frac{t}{100}} - 1\right)\right\}10^{-4}$;

Total expansion, in calories per gram, $y = 1 + \left\{0.090812t + 0.0961713\left(e^{\frac{t}{100}} - 1\right)\right\}10^{-4}$;

Excess spec. heat, per degree $y = 0.0061302t + 0.0200392\left(e^{\frac{t}{100}} - 1\right)$.

The constants in these equations were obtained by the least square method from the data of observation.

[6] Neues Jahrbuch für Mineralogie, **2**: 138–158. 1910.

minations of the mean specific heats of quartz at 100°, 300°, 500°, 550°; also of the mean specific heats of two normal silicates, albite and microcline, which do not have low temperature inversion points. From these values the total heats were computed. The specific heats of quartz were consistently higher than those of albite and microcline which behave like other normal silicates in their specific heat values. The differences between the total heats of quartz

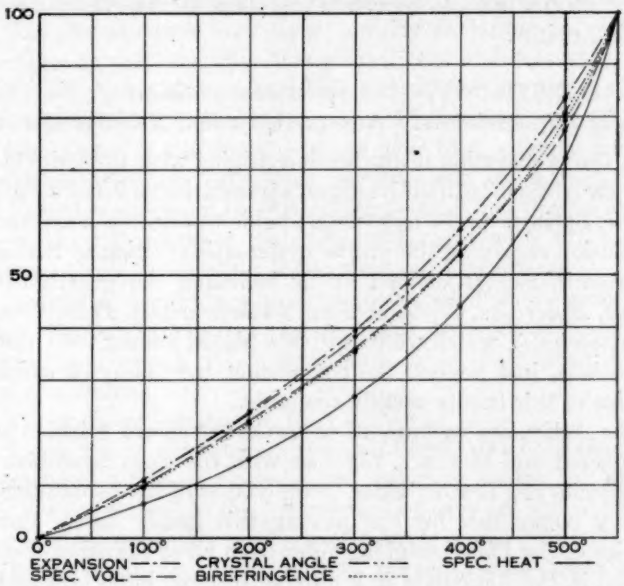

Fig. 2

and microcline for the different temperatures are plotted in figure 2. The general shape of this curve is similar to that representing the change in crystal angles except that its curvature is greater and approaches that of a circular arc. Altho part of this difference in shape may be due to experimental error in the different sets of values yet it is an appreciable difference and may express relations of which we are at present unaware. It is evident, however, that in a general way the relative changes in the crystallographical and optical properties of quartz with temperature follow

the changes in its excess energy content. In calcite the change in crystal angles with temperature is practically linear up to 600°. This indicates that in quartz the excess in energy content represents an internal reaction or equilibrium condition which eventually causes the inversion. It will be of interest to study other minerals, showing inversion points, with respect to their energy content and crystallographical and optical properties at different temperatures; also to ascertain the form of the curves near the melting points.

PALAEONTOLOGY.—*The systematic position of the Crinoid family Plicatocrinidae.* AUSTIN H. CLARK, National Museum.

In the preparation of the section dealing with the Crinoidea in the new edition (1913) of Eastman's translation of Zittel's *Palaeontologie*, Springer and Clark[1] were unable to come to a satisfactory conclusion regarding the proper systematic position of the family Plicatocrinidae (as defined by us including the genera *Plicatocrinus, Hyocrinus, Gephyrocrinus, Thalassocrinus, Ptilocrinus* and *Calamocrinus*), which we tentatively placed among the Crinoidea Articulata, just beyond the comatulids, the young of which the species in this family greatly resemble.

The Articulata include all of the other recent crinoids so far discovered and this fact, together with the close resemblance of the species of Plicatocrinidae to the young of the comatulids, was largely responsible for our placing this family here. But the species of the Plicatocrinidae differ from all of the other forms included in the Articulata in a number of most important and fundamental features.

1. The tegmen is entirely covered with a pavement of solid plates.

2. The orals are always present; they are not plane or spherical triangles, as they are in all of the (comparatively few) species of Articulata which possess them, but their edges are turned upwards so that instead of presenting five sharp angles to the mouth they

[1] When this paper was prepared and sent to press Mr. Springer was absent from Washington, but he returned to the city just before its publication. After a discussion of the subject matter he requested me to add a note stating that he is in complete accord with my conclusions as herein expressed.

meet above it in five sharp parallel edges, as do the orals of the stalked young of the macrophreate comatulids.

3. The calyx is more or less asymmetrical; the two posterior radials may be enlarged, as in *Calamocrinus*, or there may be a very small basal just to the right of the anal area, as in *Hyocrinus*. In the young of the comatulids the two posterior radials may be larger than the others, and there is always a radianal, situated more or less to the right hand side of the posterior interradius.

4. The dorsal cup is very large, entirely enclosing the visceral mass dorsally and laterally; this condition is identical with that found in the young of the comatulids, but only occurs in the adults of the Articulata in the highly aberrant *Marsupites*.

5. The plates of the dorsal cup are very thin, entirely lacking the extensive inward calcareous development so characteristic of all the other species of the Articulata; in this the Plicatocrinidae agree with the young of the comatulids, and with the highly aberrant pelagic comatulids *Marsupites* and *Uintacrinus*.

6. Instead of occupying the entire distal edge of the radials as in the Articulata (excepting only the highly aberrant *Marsupites*), the arm bases occupy only a small part, as in the stalked young of the comatulids.

7. There are no infrabasals.

8. There are no pinnules on the arm bases; proximal pinnules are, except in a few very exceptional instances among the comatulids, always present in the Articulata; but they are absent in the young of the comatulids until a considerable size is attained.

9. Tho the pinnules have essentially the same basal structure as those of the Articulata, they are in all ways more generalized, and suggest in many ways ramules or degenerate arm branches rather than perfect pinnules of the Articulata type; in this they resemble the pinnules of the very young comatulids, or of the growing tip of the arm in larger specimens.

10. The apex of the dorsal cup shows a tendency to form a concavity for the reception of the column.

11. The column lacks all trace of the modified columnal known as the proximale, but adds new segments at its summit thruout life; in this respect the column resembles that of the young coma-

tulids before the appearance of the final stem segment, which eventually will come to form the centrodorsal.

12. There are no cirri; the column is attached by a heavy terminal stem plate as in the young of the comatulids.

A few words of explanation regarding the column of the Articulata may not be out of place here. The column of the Articulata (entirely absent in the Comatulida Innatantes, the one suborder of comatulids not represented in the recent seas) is entirely different from that of any other crinoids for, instead of growing continuously thruout life thru the formation of columnals just under the crown, it possesses a definite growth limit at which further increase in the number of columnals abruptly ceases, and the last columnal to be formed becomes attached to the calyx by close suture (usually fusing with the infrabasals), enlarges, and becomes the so-called proximale which is, to all intents and purposes, an apical calyx plate. Immediately below this enlarged columnal or proximale is another more or less modified columnal to which it is attached by a modified close suture, the so-called stem syzygy which, except for a superficial resemblance, has nothing in common with the brachial syzygies.

The typical form of the column in the Articulata is seen in the young of the comatulids at the time of the formation of the centrodorsal; but this typical form persists in the adults only in the genus *Thiolericrinus*, and in the family Phrynocrinidae. In such types as the Apiocrinidae the proximale is so enormously enlarged that it involves with itself in this process a considerable number of the columnals beneath it, so that a cone shaped series of enlarged columnals is formed, each of which is a reduplication, progressively less perfect, of the proximale just beneath the calyx. Essentially the same state of affairs is seen in the Bourgueticrinidae, especially in the recent genus *Ilycrinus*. In the comatulids (excepting in the Innatantes, which never possess one) the column is discarded at the stem syzygy between the proximale and the columnal just beneath it.

In the young pentacrinite the proximale is formed exactly as in the young comatulid; but the great excess of column growth induces the formation of new columnals between the proximale and

the calyx before the proximale has time to become attached; the proximale therefore becomes pushed away from the calyx, but exactly as in the case of the comatulids, cirri are protruded from it, and it becomes united to the columnal just below it by a stem syzygy, these two columnals now forming what is known as a nodal and an infranodal, the nodal (with the cirri) being in origin a true proximale, and the infranodal the columnal just beneath the true proximale. Following the formation of this first nodal the pentacrinite proceeds to grow an entirely new column, of which the first nodal represents the terminal stem plate; this second column grows to a definite length, and then the same nodal forming process is repeated. Each pentacrinite nodal with the series of internodals beneath it, therefore, is morphologically the equivalent of the entire column in such types as the Apiocrinidae, Phrynocrinidae, or the comatulids.

In the adult pentacrinites only nodals are formed just beneath the calyx, so that here we have a series of reduplicated proximales, just as in the Apiocrinidae; but none of these nodals become attached to the calyx, for they are constantly being pushed away from the calyx by the formation of new nodals. At a little distance from the calyx intercalated columnals begin to appear between them, with the nearest of which they always unite themselves by syzygy, so that at a somewhat greater distance from the crown the nodals (proximales), united by syzygy to the infranodals, with which they form syzygial pairs, become regularly spaced, forming the typical pentacrinite column as we commonly find it.

In the bourgueticrinoid type of column any two of the columnals may be united by stem syzygy; these double columnals are rare in the distal portion of the column, but increase in frequency toward the crown. Each of these syzygially united pairs of columnals represents an effort to form a proximale which, thru excessive stem growth, has been thrust away from the calyx exactly as in the case of the pentacrinites. In addition to these there is just under the crown a definite series of proximales, corresponding to the continuously growing and indefinite series found in the pentacrinites. To emphasize the essential similarity of the

columns of the pentacrinites and of the Bourgueticrinidae it may be mentioned that the earliest nodals in the young pentacrinite column resemble far more the syzygially united columns in the bourgueticrinoid column than they do the nodals of the adult, for they are much elongated, and the cirri are usually defective, three, two, or sometimes only one, in number.

It is evident that the structure of the Plicatocrinidae in all of its details corresponds very closely to that of the young comatulids before the appearance of the columnal which is eventually to form the centrodorsal; it is also evident that this family can scarcely find a logical position among the Articulata, from all of the other forms in which it differs so radically.

The order Inadunata of Wachsmuth and Springer includes Crinoidea in which the arms are free above the radials; the dorsal cup is limited to radials, basals, infrabasals (when present) and anal plates; no interradials nor interbrachials occur except at the posterior (anal) side, and the brachials are never incorporated in the cup; all the plates of the cup are united by close suture; the mouth is subtegminal; the column is circular in section (with very rare exceptions), without a proximale.

It is at once evident that the Plicatocrinidae agree with the members of this order far better than they do with those of the Articulata, differing only in a lack of a distinct differentiation of the posterior area, and in the possession of open food grooves and an open mouth. But in the Encrinidae, which are referred to this order, the posterior area is in no way different from the others, while in at least three of the recent genera of the Plicatocrinidae it is not quite the same, so that this difference is very slight. In many of the fossil Inadunata we do not know the disk; while among recent types the genera of the Plicatocrinidae have the deepest food grooves and the nearest approach to a subtegminal mouth; it may be that in reality this apparent difference is nonexistent.

A rapid survey of the various families of the Inadunata— in the suborder Larviformia the Stephanocrinidae, Pisocrinidae, Haplocrinidae, Allegecrinidae, Synbathocrinidae and Cupressocrinidae, and in the suborder Fistulata the Hybocrinidae, Heterocrinidae,

Anomalocrinidae, Cremacrinidae, Catillocrinidae, Belemnocrinidae, Dendrocrinidae, Crotalocrinidae, Cyathocrinidae, Botryocrinidae and Poteriocrinidae—cannot fail to give the impression that there is certainly more than a superficial similarity between these types and the Plicatocrinidae. As an interesting point it may be noticed that the systematic interrelationships within the family order Inadunata are decidedly heterogeneous, and the same character is clearly reflected within the family Plicatocrinidae.

While the Plicatocrinidae, broadly speaking, may be said to agree perfectly with these families collectively—that is to say the characters presented by the component species may all be matched in the order Inadunata and in no other order—the family cannot definitely be assigned to any certain position. Therefore the most logical position for the Plicatocrinidae appears to me to be within the order Inadunata, at the end of the series of families, beyond the Poteriocrinidae.

Long ago (1899) Dr. F. A. Bather reached the conclusion that the Plicatocrinidae (which he divided into Plicatocrinidae and the Hyocrinidae) were really inadunate forms, and he accordingly included them in the Inadunata, which he considered as comprising the Hybocrinidae, the Stephanocrinidae, the Heterocrinidae, the Calceocrinidae, the Pisocrinidae, the Catillocrinidae, the Zophocrinidae, the Haplocrinidae, the Allegecrinidae, the Synbathocrinidae, the Belemnocrinidae, the Plicatocrinidae, the Hyocrinidae and the Saccocomidae.

Of the four great orders of crinoids, two, the Camerata and the Flexibilia, range from the Ordovician thru the Carboniferous. The Inadunata began in the Ordovician, one (possibly two) families persisting to the Permian, and one to the Trias, in which horizon the stalked pentacrinites were already developed. The Articulata began, so far as we can ascertain, in the Trias, and all of the fossil types (excepting only the Thiollericrinidae and the Eugeniacrinidae) persist in the recent seas. It is thus not at all surprising that we should find in the recent seas, in addition to the dominant Articulata, a remnant of the Inadunata.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Triangulation along the west coast of Florida.* CLARENCE H. SWICK. Special Publication No. 16, U. S. Coast and Geodetic Survey. 1913.

This publication gives the results of triangulation done by the Coast and Geodetic Survey and the Engineer Corps, U. S. Army, on the west coast of Florida from Cape Sable to the Alabama boundary and from the inland town of Gainesville to the coast at Cedar Keys. This, together with Appendix No. 6, U. S. Coast and Geodetic Survey Report for 1911, gives all the available triangulation data for the State of Florida.

Altho only of tertiary accuracy, this triangulation has a great practical value in that it furnishes to the geographer and to the engineer the geographic positions of more than 1150 points all correlated on one geodetic datum. The observations involved extend over a period of more than sixty years and some of the stations are lost, but in the bays and harbors and at other important places along the coast new triangulation supplements the old, and, as a rule, the more recent points are permanently marked and may be recovered without difficulty. There is given the latitude and longitude of each station and the azimuth of each line observed over; also all available descriptions of the location and marking of the stations. A series of sketches and an index of stations make it possible to find readily the data for any point or locality.

C. H. SWICK.

GEOPHYSICS.—*Note on the temperature in the deep boring at Findlay, Ohio.* JOHN JOHNSTON. Am. Jour. Sci., (4) **36**: 131–134. 1913.

A record of a series of temperature observations made in a hole drilled to a depth of 3000 feet in the neighborhood of Findlay. The temperature gradient in the sedimentary rocks at horizons between 1100 and 2600 feet proved to be about 0°.41C. per 100 feet, which is smaller than what has been considered the common average value of this gradient.

J. J.

PHYSICS.—*La mesure des températures élevées par le thermomètre à gaz.* ARTHUR L. DAY and R. B. SOSMAN. J. d. Physique (5), **2**: 727–749; 831–844; 899–911. 1912.

A translation into French, by Prof. P. Chappuis, of "High Temperature Gas Thermometry" (Publication of the Carnegie Institution of Washington, No. 157, 1911). The material has been somewhat condensed and rarranged, and the later work on the revision of the lower portion of the high temperature scale and on the boiling point of sulfur ("The nitrogen thermometer scale from 300° to 630° with a direct determination of the boiling-point of sulfur. Am. J. Sci. (4), **33**: 517–533. 1912) added. A. L. D.

ELECTRICITY.—*The analysis of alternating current waves by the method of Fourier, with special reference to methods of facilitating the computations.* F. W. GROVER. Scientific paper 203, Bull. Bureau of Standards. 1913.

The natural method for the analysis of alternating electromotive force and current curves is by means of the classic equations of Fourier, but on account of the labor involved, recourse is often had to graphical or approximate methods. Runge has shown that, by grouping similar terms, the number of terms, which need to be calculated in the Fourier method, may be materially reduced, but his work does not seem to be generally known. The present paper has for its purpose the presentation of the method of Runge in a form which shall be of especial service in making numerical computations. By systematic arrangement of the work, and by use of tables given, the labor of calculation has been very considerably reduced. Examples of the analysis of actual, experimentally obtained curves are given, which illustrate the methods of computation, and the practical applications which may be made of the results of the analyses. F. W. G.

PHYSICAL CHEMISTRY.—*The physical chemistry of Seger cones.* ROBERT B. SOSMAN. Trans. Am. Ceramic Soc., **15**: 482–498. 1913.

The relation of certain simple principles of physical chemistry to the behavior of the Seger pyrometric cones, which are widely used in the ceramic industry for the indication of heat effects in the kilns, was illustrated by experiments and charts. The high temperature cones Nos. 28 to 42 form a simple two-component series composed of alumina and silica. Their behavior agrees well with the known properties of this system, taking into account the three retarding influences: (1) lack of initial homogeneity, (2) slow rate of fusion of silica, and (3) high

viscosity of the melt. Cones 5 to 27 are made up of four oxides. It is possible to discuss them, however, as a three-component system of orthoclase, calcium silicate, and aluminum silicate, with excess silica as a relatively inactive addition. In this system, as in the foregoing, the control exercised by the low-melting eutectics upon the indications of the cones is well brought out. R. B. S.

GEOLOGY.—*Are quantitative physico-chemical studies of rocks practicable?* ARTHUR L. DAY. Comptes Rendus Congrès International Géologique XI, Stockholm, 1910. Vol. II, pp. 965–967.

An address before the Section on Mineralogy and Petrography of the Eleventh International Congress of Geologists, in which an effort was made to show by reference to recent laboratory studies of simple mineral relations, using physico-chemical methods, that these methods must eventually find application in the study of the very complicated mineral systems (the igneous rocks) also. A. L. D.

GEOLOGY.—*The volcanoes and rocks of Pantelleria.* HENRY S. WASHINGTON. J. Geol., **21**: 653–670. 1913.

Ths island of Pantelleria was studied in September, 1905, and the paper describes both the volcanic structure and the petrography of the very interesting lavas.

Pantelleria (which lies about half-way between Tunis and Malta) is entirely volcanic. It consists of an early, large cone, composed of trachytes and pantellerites. After a large explosive caldera was formed in this, a second volcanic phase began, consisting of the building up of a trachyte core within the caldera. Later this was faulted and a large block tilted down, smaller cones and flows of glassy pantellerite being poured out about this. Volcanism ceased with the formation of many small basaltic cones on the flanks of the earliest cone.

The important lavas are described in great detail, seventeen complete chemical analyses having been made. The trachytes and pantellerites are interesting because they carry abundantly well developed crystal of soda-microcline, an unusual feldspar, the crystals of which are to be investigated optically and chemically later. The latter rocks are also noteworthy for their content in the rare, triclinic, sodic amphibole, cossyrite. The basalts are of a common type, but their occurrence here in connection with such highly sodic rocks is of interest.

The relations of the lavas to the volcanism were examined, and there is a probable connection between the successive changes in the magma and the phases of volcanicity, a feature apparently here recognized for

the first time. Such a connection would be of great volcanologic importance, and as there is evidence of its obtaining at other volcanic centers, it will form the subject of future investigation.

The analyses of these rocks made by the author show that all the earlier analyses, which have been very often cited, are subject to serious analytical errors. The paper closes with a comparison of the Pantellerian lavas with those of other regions. H. S. W.

PETROLOGY.—*The index ellipsoid (optical indicatrix) in petrographic microscope work.* FRED. EUGENE WRIGHT. Am. Jour. Sci. (4), **35**: 133–138. 1913.

In this paper the importance of presenting the subject of microscopical petrography consistently from the viewpoint of the index ellipsoid as applied to wave-front normals is emphasized. The various optical properties employed in practical petrographic microscope work can be best described and explained systematically, by means of the index ellipsoid. The use of the so-called "axes of elasticity," **a**, **b**, **c**, or X, Y, Z, in this connection is confusing and only adds to the difficulties encountered by the observer in mastering the subject. They should accordingly be abandoned and the French usage of naming the principal axes of the index ellipsoid, α, β, γ (or n_p, n_m, n_g) adopted. This applies in particular to the different modes now in vogue for expressing extinction angles. For a given crystal face an extinction angle is simply the angle between a definite crystallographic direction on the face and one of the axes, α' or γ', of its optic ellipse, and this fact should be indicated in the expression for the extinction angle. To introduce "axes of elasticity" (**a'**, **c'**, or X', Z') in this connection is not only needless but less direct, as it introduces entirely new conceptions which, experience has shown, only tend to bewilder the student. F. E. W.

MINERALOGY.—*Two varieties of calciovolborthite(?) from Eastern Utah.* W. F. HILLEBRAND and H. E. MERWIN. Am. Jour. Sci. (4), **35**: 441–445. 1913.

From chemical studies, two minerals from Paradox Valley, Colorado, are considered to be varieties of calciovolborthite. In the absence of optical data concerning the original mineral, the following optical properties, determined from one of these varieties, are assigned to calciovolborthite. Color, yellow-green, with no distince pleochroism; biaxial, with strong inclined dispersion; optically negative for blue and positive for red; $\alpha_{Na} = 2.01$, $\beta_{Na} = 2.05$, $\gamma_{Xa} = 2.10$. The optical properties give evidence of monoclinic symmetry. W. F. H.

CRYSTALLOGRAPHY.—*The simultaneous crystallization of calci e and certain sulfides of iron, copper and zinc.* H. E. MERWIN. Am. Jour. Sci. (4). 1913.

The study of three occurrences of the sulfides of ron and zinc has established the certainty of the deposition of marcasite and the strong probability of the deposition of wurtzite contemporaneously with calcite. The marcasite is d finitely oriented with regard o the calcite and also to accompanying pyrite. A close similarity between the crystallogra hic elements of pyrite and marcasite is shown. H. E. M.

BOTANY. *Le fruit mûr et les jeunes semis de l'Aeglopsis Chevalieri.* WALTER T. SWINGLE. Bull. de la Soc. bot. de France, **60**: 406–409, Fig. A, No. 5, séances de mai-juin, Sept. 15, 1913.

As a supplement to the original description of *Aeglopsis Chevalieri*, the structure of the ripe fruit and the mode of germination are described in detail. The shell of the fruit is less woody than that of the other genera of the hard-shelled group of citrous fruits with the exception of Chaetospermum. The fruits are slightly pyriform at the base and often show a low protuberance at the apex. The peel is brilliant orange-brown. The membrane separating the cells is very thin, making them triangular in shape. They are filled with large flattened seeds immersed in a sticky transparent amber-colored aromatic fluid. The shell of the fruit is made up of two layers, the brilliantly colored hardened glandular skin, and a woody layer, on the inside of which there are numerous small glands. It is thought that these may secrete the sticky fluid surrounding the seeds. A seven-celled fruit is figured in cross and longitudinal section.

The seeds germinate quickly and the cotyledons, altho they turn green remain underground but near the surface. The first pair of leaves are opposite, sessile and cordiform. There is also a second pair of opposite leaves which are distinctly petiolate. This plant differs from all others of the tribe *Citreae* hitherto studied in having this second pair of opposite leaves. MAUDE KELLERMAN.

ZOOLOGY.—*A Revision of the crinoid family Mariametridæ.* AUSTIN HOBART CLARK. Proceedings of the Biological Society of Washington, **26**: 141–154. 1913.

The family Mariametridæ, as here revised, includes six genera, *Pontiometra*, *Oxymetra*, *Liparometra* (nov.), *Lamprometra* (nov.), *Dichrometra* and *Mariametra*, to which forty-nine described species are assigned. The range of each genus is given, together with the reference to the original description. A key showing the differential characters of the genera is included. A. H. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 86th meeting of the Washington Academy of Sciences, a joint meeting with the Anthropological Society of Washington, was held in the Auditorium of the New National Museum, on Monday evening, October 20, 1913.

His Serene Highness, the PRINCE OF MONACO, gave a lecture on *Researches in oceanography and anthropology*, illustrated with lantern slides and motion pictures.

The various ingenious devices used in the manifold branches of oceanography were described by the speaker, and their operation on his own yacht clearly illustrated by a number of moving pictures—pictures that showed not only how the work was done, but also the alertness and the zest of the investigator to learn new facts.

The remarks on anthropology were confined chiefly to an account of the reasons for, and uses to be made of, an Anthropological Institute which, thru the speaker's generosity, is being established in Paris.

W. J. HUMPHREYS, *Recording Secretary.*

THE CHEMICAL SOCIETY

The 228th meeting was held in Baltimore, at the Physical Laboratory of the Johns Hopkins University, on May 17, 1913. The meeting was called to order at 8.25 p.m. by W. W. Randall. The following papers were presented:

The theory and application of the selenium cell, by A. H. PFUND. Discussion by Sidell, Cox, Acree and Randall.

The absorption spectra of solutions (Illustrated), by J. SAM GUY.

C. P. VAN GUNDY, *Secretary* pro tem.

The 229 meeting was held at the Cosmos Club, on October 9, 1913. The following papers were read:

Equilibrium in the system alkali carbonate-silica, PAUL NIGGLI of the Geophysical Laboratory. Presented by JOHN JOHNSTON. The system M_2O-SiO_2-CO_2 has been experimentally investigated for the alkali metals sodium, potassium, and lithium. The changes in weight were determined of mixtures of alkali carbonate and silica, under one atmosphere of carbon dioxide, at various accurately measured temperatures. The paper appeared in full in the November *Journal of the American Chemical Society.* The paper was discussed briefly by Foster and Johnston.

New crystalline silicates of potassium and sodium by G. W. MOREY of the Geophysical Laboratory. The bomb used for heating mixtures in the presence of water at high temperatures was described and shown. The properties of the new silicates and silicate-water melts which have been prepared were then briefly covered, and samples were shown. The paper will appear in full in the *Journal of the American Chemical Society*.

Reports from the Rochester meeting of the general Society were made as follows: C. L. Parsons, on the proceedings of the Council; R. C. Wells, on the physico-chemical papers; I. K. Phelps, on biochemistry; J. A. LeClerc, on agricultural chemistry, papers on hygiene, and excursions; M. X. Sullivan, on various papers not mentioned in the other reports; Hillebrand and Bigelow, on the Smoker; Walker, on the coal analysis discussion; and Cameron, on the fertilizer section. The question of agreement on analytical methods, raised by Cameron, was discussed by Hillebrand, who pointed out the need of testing the homogeneity of standard samples before sending them out.

The question of the absorption of the *American Chemical Journal* by the American Chemical Society was discussed at some length. The meeting decided to take no action in opposition to the decisions of the Council and Directors of the general Society.

The 230th meeting was held at the Cosmos Club, on November 13, 1913. The President appointed the following committee to represent the Society at the McGee Commemorative Meeting on December 5. F. W. Clerke, W. Blum, F. K. Cameron, W. F. Hillebrand and D. T. Day.

The election of officers for 1914 resulted as follows: *President*, M. X. SULLIVAN, Bureau of Soils; *First Vice-President*, C. L. ALSBERG, Bureau of Chemistry; *Second Vice-President*, H. H. BUNZEL, Bureau of Plant Industry; *Secretary*, R. B. SOSMAN, the Geophysical Laboratory; *Treasurer*, F. P. DEWEY, the Mint; *Councilors*, J. A. LECLERC, L. M. TOLMAN and P. H. WALKER of Bureau of Chemistry, and S. F. ACREE of Johns Hopkins University; *Executive Committee*, E. C. MCKELVY of Bureau of Standards, R. C. WELLS of Geological Survey, J. JOHNSTON of Geophysical Laboratory and E. W. BOUGHTON of Bureau of Chemistry.

ROBERT B. SOSMAN, *Secretary*.

THE BOTANICAL SOCIETY OF WASHINGTON

The 13th annual meeting of the Botanical Society of Washington was held at the Bureau of Plant Industry on October 17, 1913, with seventeen members present. The customary reports were presented and approved and the following officers elected for the ensuing year: *President*, C. L. SHEAR; *Vice-President*, A. S. HITCHCOCK; *Recording Secretary*, C. E. CHAMBLISS; *Corresponding Secretary*, P. L. RICKER; *Treasurer*, H. H. BARTLETT. Mr. F. L. LEWTON was nominated as Vice-President from the Society for the Washington Academy of Sciences.

The 90th regular meeting of the Botanical Society of Washington was held on October 6, 1913, at the Cosmos Club with forty-two members and seventeen guests present, including the following distinguished European botanists: Frau Dr. BROCKMANN-JEROSCH, Zürich; Dr. EDWARD RÜBEL, Zürich; Prof. CARL SCHRÖTER, Zürich; Prof. C. VON TUBEUF, Münich.

The program consisted of brief informal remarks, as follows:

President STOCKBERGER: An address of welcome to the guests of the Society.

Mr. WALTER T. SWINGLE: *Citrus plants of the world and their importance and use in connection with citrus culture and citrus breeding.*

Prof. C. VON TUBEUF: *A brief summary of the results of twenty years' work with the mistletoe.* (Translated by Prof. Schröter).

Mr. DAVID FAIRCHILD: *Plant introduction work of the Bureau of Plant Industry.*

Prof. CARL SCHRÖTER: *Impressions received during the American International Phyteographic excursion.*

Mr. CARL KELLERMAN: *Nodule production and nitrogen fixation by plants other than leguminosae.*

Mr. HAVEN METCALF: *The chestnut blight disease.*

Mr. W. E. SAFFORD: *Photographs of bullthorn acacias.*

The 91st regular meeting of the Botanical Society of Washington was held on November 4, 1913, at the Cosmos Club with forty-six members and five guests present.

Dr. HARRY B. HUMPHREY and Messrs G. C. HUSMANN and K. J. J. LOTSY were elected to membership.

The action of the retiring Executive Committee relative to the giving of a dinner in honor of the seventieth birthday of Dr. EDWARD L. GREENE was called to the attention of the Society by the President and a committee was appointed to arrange the details.

The following scientific program was presented:

Abbreviations used in the citation of botanical literature. Prof. A. S. HITCHCOCK. The speaker pointed out the different methods used for abbreviating citations, the extreme contraction on the one hand, such as "O B Z" (Oesterreichische Botanische Zeitschrift), and on the other the elaborated citations used by some authors in the Pflanzenreich. Abbreviations should be brief as possible consistent with clearness, but should follow a definite system. The speaker described the system followed in abbreviating citations used in the Contributions from the National Herbarium. The record of authorized abbreviations of authors and titles is indexed in a card catalog. Authors consult this record when preparing manuscript for publication, thus aiding the editor to secure uniformity.

Non-parasitic foliage injury. Mr. CARL P. HARTLEY. Notes were given on the effects of drouth and storm on leaves of ornamental trees at Washington, D. C., for the past season. June and July were hot and dry, with but 35 per cent of normal rainfall. Norway maple, es-

pecially in street planting, suffered most from drouth, the margins of leaves being killed; in the worst cases whole leaves except parts immediately adjoining the veins died. Most other trees, including *Acer rubrum*, escaped serious leaf injury. A northeast storm with hail and a 66-mile wind at the end of July injured many species, especially sugar maple and American basswood. The storm injury to maple resulted in the death of part of the leaf at the margin and between the veins, without laceration or other external indication of mechanical injury. These storm-injured maple-leaves could be distinguished from those hurt by drouth only by their limitation to parts of trees especially exposed to the storm.

Pitfalls in plant pathology. Dr. H. W. WOLLENWEBER. A revision of the hundreds of species of Fusarium in literature has led the speaker to believe that the genus Fusarium contains only 30 to 50 different forms. A sharp criticism was given to mycologists who send unreliable specimens to the international "Pilzcentrale" in Amsterdam. Many errors are caused by the earlier opinion that Fusaria as a rule are adapted to one particular host. Upon receiving a request for a particular wound-parasitic Fusarium even the author of that species is liable to make the following mistake. He isolates from a diseased specimen a fungus, which he sends to the inquirer when it has produced sickle shaped spores which he thinks belong to species previously described by him. Upon a second request perhaps a year later he would isolate similarly from another specimen of the same host presuming to obtain the same fungus. The speaker by chance checked up the strains sent under the same name to three different places at various time by the same author and found two different species. Careful reference to the source and the method of isolations and determination are required to eliminate mistakes of this sort.

If one is unfamiliar with the method used to develop sporodochia with normal spores he might consider a subnormal spore as normal. This leads to another pitfall, where diagnoses of the same species disagree and the subnormal fungus is described as new. An example of this kind is *F. trichothecioides* Wr., wound parasite of the potato, a fungus the early stage of which is described as *F. tuberivorum* by Wilcox and Link.

Nectria ipomoeae Halsted is mentioned as an example of a species furnishing many pitfalls. This is a cosmopolitan saprophytic ascomycete which crosses the path of various specialists. This fungus is called *Nectria ipomoeae* when isolated from Ipomoea, *N. coffeicola* when from Coffea, *N. cancri*, when from canker spots of Theobroma, *N. vandae* when from Vanda.

Nectria discophora Mont. has been four times described as a new species by Paul Hennings, as pointed out by v. Höhnel and Weese, simply because it looked different when collected from various hosts in different stages of its development. In pure culture all these stages could be easily imitated by special treatment and the mistakes once discovered lead to a remarkable simplification of the nomenclature.

The perfect form has been obtained from various fungi with Fusaria-like spore forms. They belong to such genera as Gibberella, Nectria, Hypomyces, Calonectria and Neocosmospora. But the conidia of these ascomycetes have not sufficient relationship to Fusaria without known perfect form to justify identification with any species of Fusarium sections, such as *elegans, discolor, martiella, roseum* and *gibbosum*.

In neglecting such facts we would be exposed to a pitfall in the following case: *Fusarium culmorum* W. G. Smith (*F. rubiginosum* App. & Wr.) has conidia looking so much like small conidia of *Gibberella Saubinetti* (Mont.) Sacc. that they seem to be identical. The former, however, develops chlamydospores and no perfect form, the latter no chlamydospores but the perfect form under culture conditions. If we overlook this we may conclude after having proved one strain to have *Gibberella perithecia*, that we also have proved *F. culmorum* to be a Gibberella. Literature is rich with such errors.

Sections of a fossil wood from asphalt lake near Los Angeles, Cal. Dr. ALBERT MANN. Thin sections of the petrified wood were exhibited under a microscope which showed fungus hyphae. Brief notes were given as to the apparent method of the growth of the fungus and the possible identification of the tree was discussed.

P. L. RICKER, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 414th regular meeting was held at the Cosmos Club on October 18, 1913, with former President L. O. Howard in the chair and 61 persons present.

The program consisted of three communications:

The Federal migratory bird regulations and their assistance in the conservation of bird life in America: T. S. PALMER. The speaker outlined briefly the history of the Weeks-McLean Bill, approved March 4, 1913, and of the adoption of regulations for its enforcement which have been promulgated by the Department of Agriculture under proclamation of the President dated October 1, 1913. Maps of the winter and breeding ranges of some of the species of birds affected were shown, together with another showing the division of the country into two zones. Reasons were given for the exceptions in certain States to the general closed season. In general the beneficial effects upon the bird life of the country expected as a result of the enforcement of the Federal law were pointed out. Hugh Smith and Col. Joseph H. Acklen took part in the discussion which followed.

The breeding of the loggerhead turtle: W. P. HAY. The communication was accompanied by lantern slides. It was an account of observations of the habits and reproduction of the diamond-backed terrapin and the loggerhead turtle made at Beaufort, North Carolina. This place is near the northern limit of the distribution of the loggerhead turtle and the speaker was of the opinion that normally in this latitude few of the eggs of the species are left to hatch and that the young from those that may hatch all perish with the first cold weather.

The first year's results in breeding some Bahama shells (Cerion) on the Florida Keys: PAUL BARTSCH. A former communication by the speaker gave an account of the transfer of two races of *Cerion* from the Bahamas to various Florida Keys. The present paper was an account of observations of the condition of the new colonies at the end of the first year. In general they have prospered and in several localities have reproduced young.

The 515th meeting was held at the Cosmos Club on November 1, 1913, with President E. W. Nelson in the chair and about 50 members present.

Under the heading *Brief notes and exhibition of specimens,* C. DWIGHT MARSH related an observation in Montana of a noise made by a bull snake (*Pituophis sayi*) which was in close imitation of that made by a rattlesnake. The sounds were made by the respiratory organs and were observed by a number of persons.

REGULAR PROGRAM

A. D. HOPKINS spoke of *Depredations by forest insects and their control.* He gave a brief historical sketch of early insect invasions of forests and of the means adopted to combat the pests. The greater part of the paper was devoted to depredations of which the author had personal knowledge. The efficacy of modern methods was pointed out, especially the control work undertaken by the Bureau of Entomology in collaboration with the United States Forest Service. These have been generally adopted by large private holders of timber lands and much saving of valuable timber has resulted.

PAUL BARTSCH gave an account of the results of dredging for mollusks at Chincoteague, Virginia. In two days collecting eleven new species were found. The speaker gave an account of some personal experiences and observations on the island. He was followed by W. P. Hay, who also spoke of his experiences during a visit to Chincoteague and gave some interesting historical notes of the place.

D. E. LANTZ, *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At a special meeting of the Anthropological Society on November 4, 1913, Dr. JOHN R. SWANTON read a paper entitled *The Indian village.* Dr. Swanton stated that while it is a common notion that country life preceded urban life this view is hardly correct, urban life in its germs going back probably almost as far as man himself. He then took up the various factors tending to produce the village, determine its character, and subsequenty knit it together. These he found to be of three orders, material, social and religious. Among the first he enumerated material available for the construction of houses, position with reference to the food supply and fresh water, and occasionally also position with reference to the sun. Among social factors he treated

trade, desire for exchange of ideas, need of mutual protection and relationship, especially in the peculiar form it assumed under totemism. Finally the growth of a village or town cult was traced from the practical independence of shamanism pure and simple to the complete town ritual, sometimes directly, sometimes thru the fusion of clan ceremonies, and sometimes thru the rituals of religious or other societies. These factors were illustrated by reference to the tribes of the north Pacific coast and the gulf area. A possible evolution was suggested in three stages, first the haphazard collection of hunters, fishers, or perhaps agriculturalists, in a certain spot; second the development of social relations among them, particularly thru intermarriage, and thirdly a religious seal or stamp of unity, tho it was not the writer's intention to set this up as a hard and fast process of evolution. It was noted that totemic clans among some tribes might have been evolved in a similar manner. In conclusion a short comparison was made between the Indian village and the modern city, attention being called to the fact that in the latter the most important determining factor is trade, while in the former relationship, religious observances, and to some extent motives of protection were much more prominent.

The subject was discussed at some length by Mr. J. N. B. Hewitt, who confined his remarks to the village in the social organization of the Iroquois. The basis of the social organization was actual or fictitious blood kinship traced thru the mother. The cohesiveness of the several units was obtained thru the ties of duty and privilege subsisting between clans united by the marriage of their sons and daughters. The clans were organized into two brotherhoods of clans, one of which represented the masculine and the other, the feminine, in nature. This division was maintained in all public meetings. The one side was therefore called the "father side," and the other, the "child side," which of course was the "mother side." Strong lines of actual or artificial kinship and cleavage existed between these two groups. The clans's totems have no especial religious significance at present, that is, there are no ceremonies in honor of them. That there were such in early times is quite possible. The decadence of the worship of the clan totem was probably due to the unification of the clan government into that of the tribe, and later, of the tribe into that of the confederation. The great influence of the council of women, composed of mothers only, in the affairs of the village and tribe and confederation was emphasized, and illustrated by the effectiveness with which they could stop or prevent a war. They needed only to forbid their sons to engage in warlike activity under penalty of becoming outlaws to the tribe and confederation. The gradual adoption of the Tuscarora tribe of North Carolina by the Iroquois League on motion of the Oneidas as their sponsors was described, the Tuscaroras being first regarded as infants, then as boys who were not allowed to take part in the wars and councils of the League, and then, finally, as warriors having their chiefs to represent them in the Federal Council of the League.

Daniel Folkmar, *Secretary.*

ANNOUNCEMENT OF MEETINGS

The Washington Academy of Sciences will hold a joint meeting with the Philosophical Society on December 4 at 8.15 p.m., in the Cosmos Club Assembly Hall. Prof. JEAN PERRIN, Professor of Physical Chem istry at the University of Paris will address the Academy on *Brownian movement and molecular reality.*

NINETEENTH INTERNATIONAL CONGRESS OF AMERICANISTS, WASHINGTON, D. C., OCTOBER 5 TO OCTOBER 10, 1914

Preliminary notice

Pursuant to arrangements made at the Eighteenth International Congress of Americanists, in London, 1912, the Nineteenth Congress will meet in America in 1914 in two Sessions, the first at Washington, D. C., and the second at La Paz, Bolivia.

The Session at Washington will be held under the auspices of the Smithsonian Institution, in coöperation with the George Washington University, Georgetown University, the Catholic University of America, the Anthropological Society of Washington, and the Washington Society of the Archaeological Institute of America.

During the Session an excursion will be made to the highly interesting aboriginal quarry and workshop at Piney Branch, D. C.; and following the Congress it is expected that two excursions will be arranged, one to Ohio for the examination of ancient mounds, the other to New Mexico for the study of ancient ruined pueblos and cliff-dwellings, as well as of the present Pueblo Indians in their native environment.

To avoid delay in announcements, and to facilitate the organization of the Session, those who desire to become members are urged to communicate as soon as practicable with the Secretary, giving the titles of papers which they wish to present before the Congress, together with a brief summary of each.

ALÉS HRDLIČKA, *Secretary,*
U. S. National Museum,
Washington, D. C.